ACCRETIONS IN CEMENT SILOS : REASONS FOR FORMATIONS AND PREVENTIVE MEASURES

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SUMMARY :

The formation of lumps and accretions in cement silos are of frequent occurrence in cement plants. Some of the common influencing factors for lump formation are grinding of Portland cements to higher fineness, storage of cement for longer time, cement mill temperatures is not maintained judiciously, the cement has higher K_2O contents , aged clinker is used frequently in cement grinding or due to lack of periodic maintenance of the cement silos .

The paper discusses the chemico-mineralogical , thermal and microstructural characteristics of the cement silo ,coating / lump samples collected from two cement plants. Based on the evaluations results the authors further indicate the possible reasons for the formation of accretions .

The paper further illustrates the generally observed influencing factors and some range of chemical , physical and technical measures that could be attempted for avoiding the problems of accretions in cement silos

1.0 INTRODUCTION

The incremental expansion in clinkering capacities of cement plants through modification in the preheater systems has been observed to increase the production pressures on the cement grinding systems . The situation is further aggravated by sudden market demands of the product .This invariably results into grinding of Portland cements to higher fineness , use of hot clinker , use of aged clinker in cement grinding , lack of periodic maintenance of the cement silos lack of proper control on cement mill temperatures etc contribute to the formation of accretions in cement silos . Presence of higher sulptates in clinker resulting from the sulphur in the fuel used , presence of higher K_2O contents in clinker , higher storage capacity of cement silos, storage of cement in silos for longer time with inadequate ventilation further enhances the tendency of lump formation in the cement silos.

In this paper the authors have discussed the reported reactions leading to the formation of accretions . The diagnosis of the reasons of lump formation through the chemico-mineralogical, thermal and microstructural characteristics of the accretions is also exemplified by two case studies.

The paper finally summarises the generally observed influencing factors and some of the chemical, physical and technical measures that could be attempted for avoiding the problems of accretions in cement silos

2.0 GENESIS

Studies carried out by different researchers [1] and simulation experiments [2] conducted in different laboratories have indicated that the reactions leading to the formation of lumps in cement silos are initiated by:

- The presence of moisture arising from the evaporation of moisture in the materials (use of wet by-product gypsum) and partial loss of moisture by the gypsum during cement grinding . Gypsum gives of partially its water of crystallisation at temperatures above 45° C to form its hemi-hydrate or even its soluble anhydrite. At the temperatures of storage of ground cement in silos the quantities of water given out can be quite significant , 100kg of cement can give 1 kg of water i.e. 50 litres of water by 5000 t of cement.

$$CaSO_4 . 2H_2O \longrightarrow CaSO_4 . 0.5\ H_2O + 1.5\ H_2O$$

$$CaSO_4 . 2H_2O \longrightarrow CaSO_4 + 2\ H_2O$$

- The water vapours move to the colder areas of the cement silos preferably along the walls and tend to condense.
- In the presence of moisture the C_3A of clinker and sulphate of the gypsum form ettringite ($3CaO.Al_2O_3.3CaSO_4.32\ H_2O$).
- Presence of K_2SO_4 in clinker/cement leads to formation of syngenite

$$CaSO_4 + K_2SO_4 + H_2O \longrightarrow CaSO_4 . K_2SO_4 . H_2O$$

$$CaSO_4 . 0.5H_2O + K_2SO_4 + 0.5\ H_2O \longrightarrow CaSO_4 . K_2SO_4 . H_2O$$

- Presence of Calcium Langbeinite in clinker could also react with the water vapours to form syngenite

$$2CaSO_4 . K_2SO_4 + H_2O \longrightarrow CaSO_4 . K_2SO_4 . H_2O$$

- The ettringite and syngenite are needle like in shape . thus induce "felting". which causes lumping in cement.
- In presence of higher moisture /condensate water .C_3S also participates in the reactions .
- If alkalies are present as alkali aluminates the above reactions are further accelerated .
- Re-hydration of hemi-hydrate by the effect of moisture further entail lump formation.
- It is known that such lump formation of cement decreases the compressive strengths of cement.

The influence of the different factors on the tendency of lump formations can be summarised as follows :

Factors	Tendency of Accretions	
	Weak	Strong
Silo temperatures	low	High
Retention Time in Silos	short	Long
SO_3 contents	low	High
Gypsum dehydration in Mill	Strong	Little
Gypsum dehydration in silos	little	Strong
Sulphate carrier	anhydrite	gypsum

The reduction in crystal water content of gypsum with temperatures of cement storage [3] is shown in Fig:1 and the water vapour pressures for various component of portland cement are shown in Fig:2.

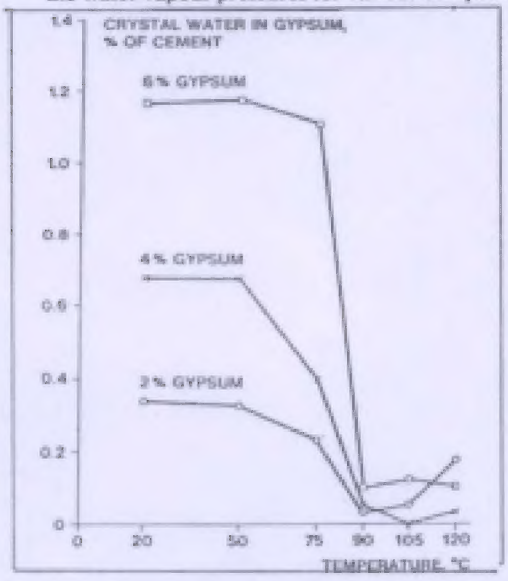

Fig: 1 % reduction water of gypsum with temperatures

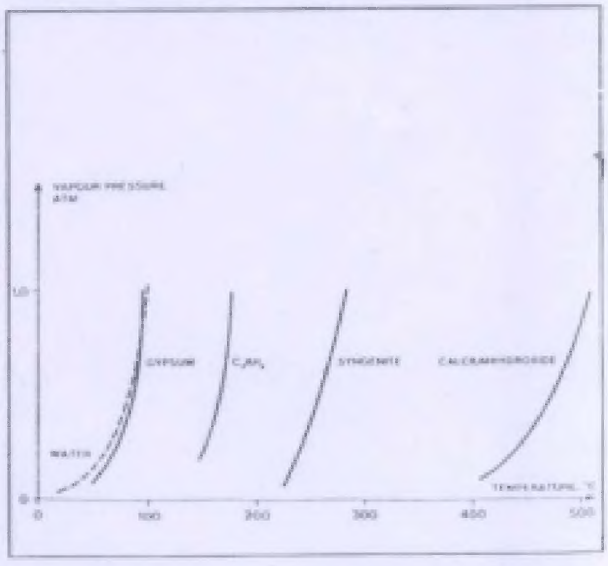

Fig: 2 Water vapour pressures of some components cement

The amount of lump formation as a function of the water lost by gypsum and its dependency on K_2O, Free CaO and Gypsum contents is graphically shown in Fig 3 (a) &(b)

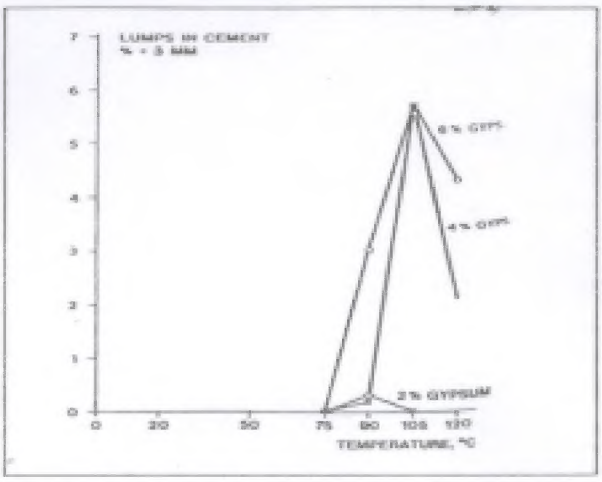

Fig:3 (a) % lumps v/s temperature

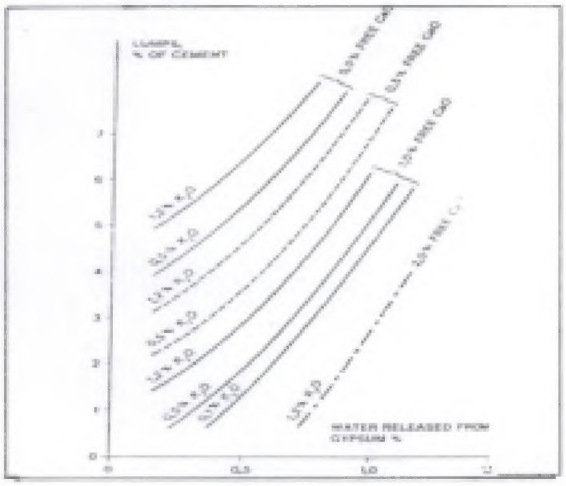

Fig:3 (b) % lumps related to freeCaO, K_2O & release water by gypsum

3.0 CASE STUDY-1 :

Heavy coating in cement silos was reported in one of the cement grinding unit of a cement plant in which slag and gypsum and clinker and gypsum was separately ground in VRM and ball mill respectively before blending to produce PSC .The accretions reduced the storage capacity of the silo and obstructed the free flow of the material by jamming the air-slides. In order to solve the problem and understand the cause of this phenomenon detailed investigation were carried out on the cement lump samples .

Evaluations , Results and Inference :

Chemical evaluation :

Oxides	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	LOI	SO_3	IR	Na_2O	K_2O	Cl
%	21.1	3.9	3.0	56.7	4.6	7.2	3.3	0.8	0.13	0.01	0.01

The analysis indicates that LOI and SO_3 content in the cement are much on the higher side the K_2O contents are low.

Megascopic observations:

The lump samples collected showed distinct two parts ,a hard surface of lighter colour nearer to wall of silo and a light grey portion which was relatively softer in nature . The thickness of hard light coloured portion was between 1.1 -1.6 mm. The two sections of the sample were sliced and analysed for mineralogy by XRD (PhilipsX'pert MPD) and for microstructural characteristics by Jeol - JSM 5400 Scanning electron Microscope .

Mineralogy

X - ray diffractograms of the hard and soft part of the sample is shown in Fig 4.

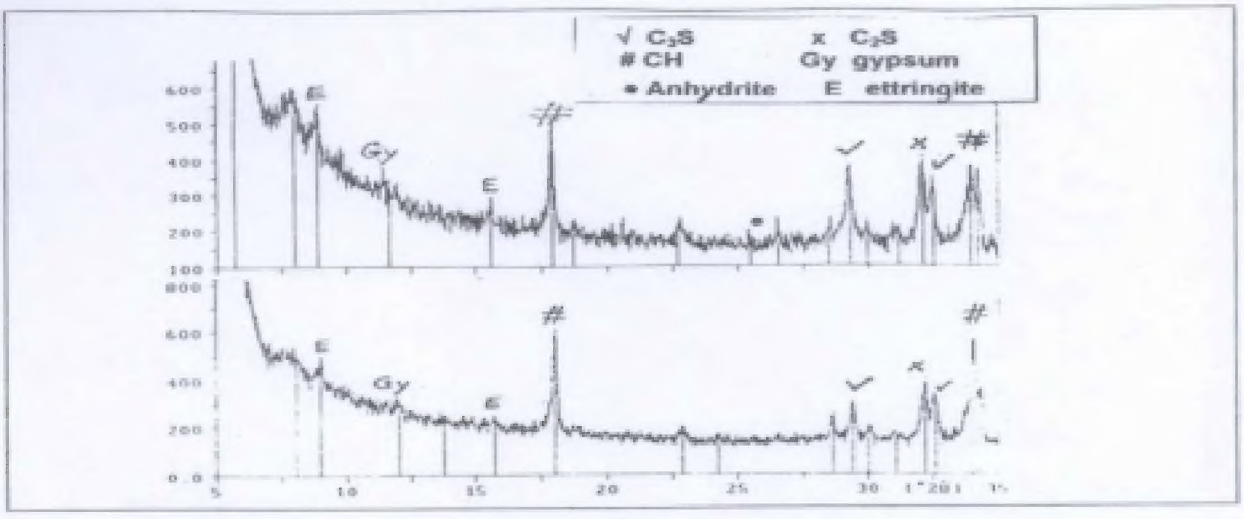

Fig : 4 XRD scan of the harder and the softer portion of the cement lump

The harder portion was observed to be composed of C_3S, C_2S.Portlandite , anhydrite , Gypsum. Ettringite while the softer outer portion showed C_3S . C_2S . Gypsum . Ettringite and lesser Portlandite . this portion was conspicuous in absence of anhydrite.

Microstructure

Under electron microscope, the hard part showed fibrous like crystals of anhydrite and gypsum. The quantity of these crystals decreases away from the hard part. Portlandite crystals are also seen in this hard part (Fig:5). However, more crystalline type is seen in the softer region of the samples. Presence of very fine needle like ettringite is also observed throughout the samples (Fig:6).

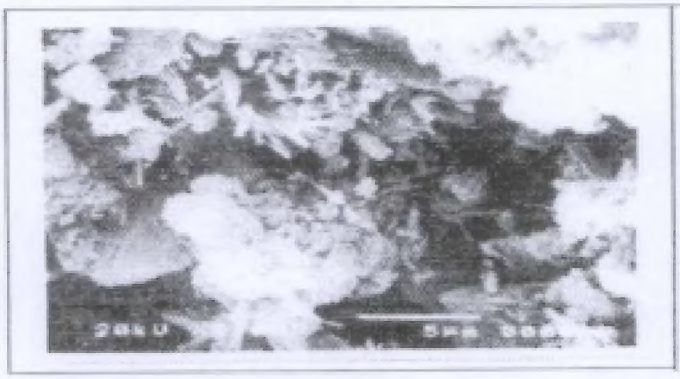

Fig:5 Anhydrite crystals, fine needles of ettringite in hard part

Fig:6 Very fine ettringite needles with prehydrated cement grains in soft part of the lumps

Causes for lump formation :

A temperature gradient in the cooler areas of the silo i.e. near to the wall which causes condensation of water which causes the hydration of the cement grains forming portlandite and developed ettringite crystals resulting into a hard crust . In this portion the water hydrates the dehydrated gypsum produced either during grinding or in the storage silo . Subsequently, more cement grains must have got adhered to this hard crust forming the softer part of lump which shows presence of gypsum and thinner crystals of ettringite .

Subsequently the grinding unit reduced the gypsum added to the slag in grinding of slag and improved ventilation in the storage silo reduced problem of lump formation.

4.0 CASE STUDY-II

This case study pertains to the Problem of lump formation experienced in one of the cement plants producing OPC. The plant was operating roller press in closed circuit and equipped with open circuit ball mill grinding with internal water spray system for controlling the temperature of cement in the grinding mill. The temperature of the cement at the outlet of the cement mill was higher in the range of 120 - 150 °C. The type of gypsum used was mineral gypsum. The cement was being stored in a silo of capacity 5500 MT. It was observed that , if the cement was stored in the silo for two to three days without extraction , problems of extraction were encountered due to the formation of soft lumps (agglomerates).

Evaluations , Results and Inference :

Chemical evaluation :

Oxides	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	LOI	SO_3	IR	Na_2O	K_2O	Cl
%	22.0	3.7	3.6	61.4	1.5	2.2	3.1	1.4	0.06	0.48	0.006

The analysis indicates that SO_3 content in the cement is on the higher side with higher K_2O contents .

The sample was analysed for thermal analysis and for mineralogy by XRD

Mineralogy

X - ray diffractograms of the sample is shown in . the sample is composed of C_3S,C_2S,C_4AF and Calcium Langbeinite ($2CaSO_4.K_2SO_4$) and traces of hemihydrate .

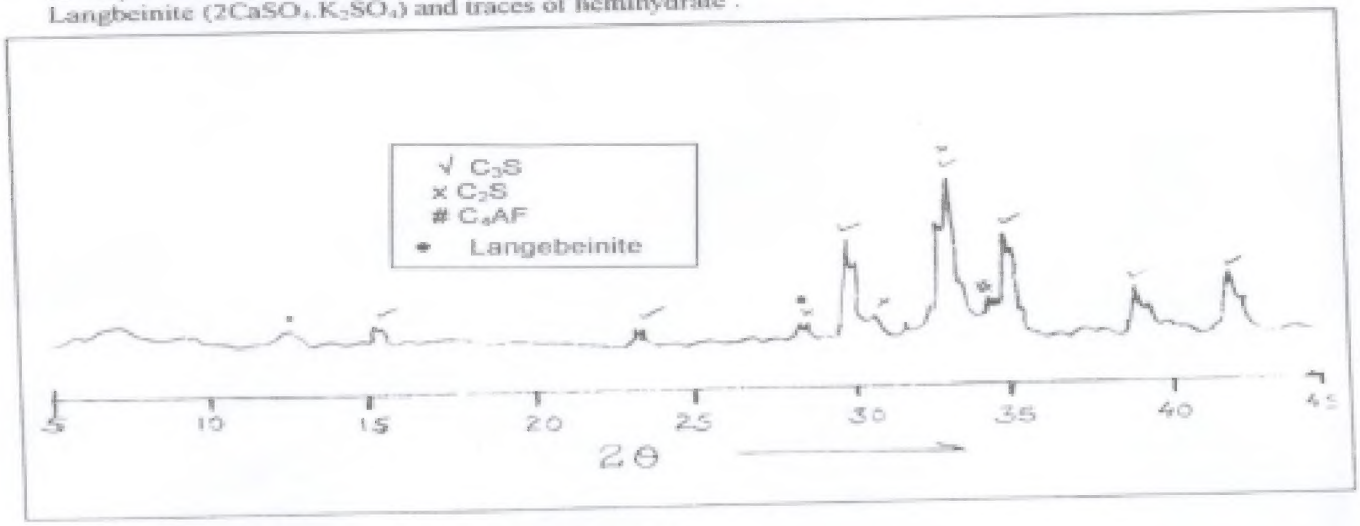

Fig : 7 XRD of the soft Lump (Case - II)

Causes for lump formation :

The evaluations carried out indicate that in this case the soft agglomeration is due to formation of syngenite traces initiated by the presence of Calcium langbeinite present in the clinker and traces of hemi-hydrate present in the cement .However this could result in harder lumps if there is sufficient water condensation in the cooler areas of silo.

The agglomeration was brought under control by reducing the gypsum levels in combination with control on the cement mill temperature . As a precaution adequate ventilation was provided in cement silo to avoid agglomeration even if the cement is stored for a longer time .

5.0 CONCLUSIONS

The case Studies discussed in the paper indicates that judicious evaluation of the accretions can indicate the possible reasons for their formation and subsequently attempts can be made to prevent such formations .

However some of the measures that could help in preventing /overcoming the problems of accretions can be summarised as follows :

- Reducing the gypsum levels in cement if possible .
- Reduction in clinker temperature as fed to the mill,preferably below 60°C .
- Optimisation of the water spray inside the mill and with provision of better ventilation in mill and in the storage silos to prevent water condensation .
- Better control on cement temperature during grinding
- Longer retention time of the cement in silo should be avoided .
- Periodic maintenance of silos
- Installing air guns or installing sonic devices for shattering the accretions .

6.0 REFERENCES :

1. Dr. Indo Driezler : "Formation of lumps and Accretion in Cement Silos and Measure to Prevent and Eliminate these Phenomenon" .**Indian Cement Review** July 1989 pp52-55.

2. Vazquez, T., Blanco-Varela, M. T. , Palomo-Sanchez , A."Lumping of anhydous portland cement. Study Through IR Spectroscopy" **8th International Congress on the chemistry of cement . Vol : VI** pp 578-581.

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